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(71) Applicant: Polymatech Co., Ltd.
Tokyo (JP)

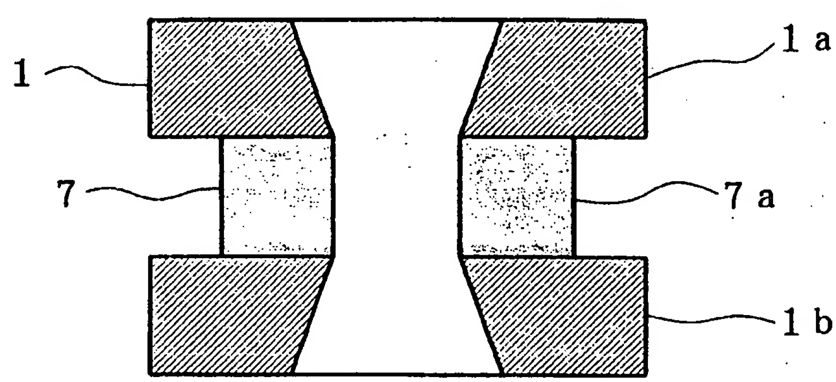
(72) Inventors:
- Itakura, Masayuki, c/o Polymatech Co., Ltd.
Tokyo (JP)
- Kidokoro, Yukihiro, c/o Polymatech Co., Ltd.
Tokyo (JP)

(74) Representative: Whalley, Kevin
MARKS & CLERK,
57-60 Lincoln's Inn Fields
London WC2A 3LS (GB)

(54) **Anisotropic damper**

(57) An anisotropic damper using an elastic member (7) having an E value two times or more larger than that of an elastic member (1) for damping the vibration in the vertical direction to a portion for supporting the rotary part (8) of an optical disk (3) or the like and a mechanical chassis (2) mounting an optical pickup (4) and to the portion for damping the vibration in the planar direction, and comprising two types of elastic members for controlling the fluctuation in the relative distance between the optical pickup and the disk.

Fig. 1



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Description

The present invention relates to a damper for reducing vibrations through vibration suppression or vibration isolation by using an elastic body for acoustic equipment, video equipment, information equipment, or various types of precision instruments, particularly for an apparatus using an optical disk medium such as a CD, CD-ROM optical disk, or photomagnetic disk.

A conventional damper for supporting a mechanical chassis of an optical disk unit and so on is a push-type damper comprising one type of elastic body having an E value of 1.0×10^{4}kg/cm^2 or less as shown in Fig. 5 or Fig. 6 of the accompanying drawings, that is a damper is generally used which comprises an elastic body constituted by holding a rotary part 8 of a medium disk 3 and a mechanical chassis 2 mounting an optical transmitter or optical receiver (hereinafter referred to as optical pickup 4) on the face side and fixing them to a box 5 with a screw 6 or the like as shown in Fig. 7.

The conventional push type damper comprising one type of elastic body has a shape shown in Fig. 5 or 6, and the ratio between spring constants in the directions vertical to and parallel with the plane of the disk 3 is between approximately 0.5 and 2 times even if spring constants are changed.

Conventionally, the characteristic requested for a damper is to provide an effect of the reduction of transmissibility of vibration acceleration by suppressing vibration so that the relative distance between the disk 3 and the optical pickup 4 can be kept constant, specifically by keeping the natural frequency due to the damper at square root of 0.5 or less to a desired frequency and therefore a spring constant to the total weight of the mechanical chassis 2, disk 3, and optical pickup 4 is obtained.

However, the rotating disk 3 produces vibration in the direction vertical to the rotation axis due to weight imbalance caused by dimensional tolerance, machining error or the like, namely in the direction parallel with the disk. Unless the damper has only a low elasticity to the vibration, the mechanical chassis itself greatly vibrates. To stop the vibration, it is necessary to control the vibration with a force larger than the angular moment due to the weight imbalance. To control the vibration, it is preferable to use a method of fixing the mechanical chassis to the box 5. However, if the ratio between spring constants of the damper in the directions vertical to and parallel with the plane of the disk 3 is within a range from approximately 0.5 to 2 times, it is impossible to stop the vibration. On the contrary, vibration having a frequency close to the natural frequency due to the damper, that is resonance, occurs and a worse result occurs.

The present invention provides a push-type anisotropic damper for supporting a mechanical chassis comprising a rotary portion of a medium disk and an optical transmitter or an optical receiver in order to prevent vibration of an apparatus for storing or regenerating data in a non-contact disk information medium such as an optical disk and a photomagnetic disk, said damper being formed by combining two types of elastic bodies or more having different E values (dynamic compression elastic modulus); and said E value of an elastic body for supporting said mechanical chassis in the direction parallel with a disk face and damping the vibration in the parallel direction with said disk face to be used for a part or the whole of a section to be installed to said mechanical chassis or a box chassis is two times or more larger than said E value of an elastic body for supporting the direction vertical to said disk face and damping the vibration in the vertical direction to said disk face.

Therefore, the present invention makes it possible to restrain the fluctuation in the relative distance between an optical unit for writing or reading data in the direction vertical to a disk face and the disk, by forming a part or the whole of a damper for holding a mechanical chassis with a low-elasticity body, and by restraining the self-producing vibration produced due to disk rotation in the disk face direction.

The invention will be further described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a longitudinal sectional view of an anisotropic damper according to the present invention in which the whole of the setting part comprises a high-elasticity body;

Figure 2 is a longitudinal sectional view of an anisotropic damper according to the present invention in which a part of the setting part comprises a high-elasticity body;

Figure 3 is a sectional view of an anisotropic damper according to the present invention in Fig. 2 in which the support part in the direction vertical to the disk face is decreased in diameter;

Figure 4 is a transverse sectional view of the part for setting an anisotropic damper according to the present invention in which a part of the setting part comprises a high-elasticity body and it is radially divided into a plurality of pieces;

Figure 5 is a longitudinal sectional view of a conventional push-type damper;

Figure 6 is a longitudinal sectional view of a conventional push-type damper in which the support part in the direction vertical to a disk face is decreased in diameter; and

Figure 7 is a longitudinal sectional view of a mechanical chassis supported with a damper.

The present invention uses a push-shaped damper for supporting a mechanical chassis without greatly changing the shape of a conventional damper.

The present invention is described below in accordance with the embodiments shown in Figs. 1 and 2.

The elastic body used for the part for supporting it in the direction vertical to the plane of a disk 3 (see Fig. 7) is a rubber-like elastic body having an E value of $1.0x10^{4k}g/cm^2$ or less (hereinafter referred to as low-elasticity body 1). The E value of $1.0x10^{4k}g/cm^2$ or less corresponds to 70 hardness or less in terms of the JIS (Japan Industrial Standards) rubber hardness class A. Therefore, the rubber-like elastic body has a general rubber elasticity. Moreover, the elastic body used for the mechanical chassis serving as a part for supporting it in the direction parallel with the disk, or for the whole 7a or a part 7b of the cylindrical portion installed to the box chassis is an elastic body (hereinafter referred to as high-elasticity body 7) having an E value two times or more larger than the E value of the low-elasticity body.

A damper of the present invention is characterized by combining and integrating the low-elasticity body 1 and the high-elasticity body 7 having different E values from each other, and thus by suppressing by a low-elasticity body the vibration from the outside to the inside of a mechanism causing fluctuation in the relative distances between an optical pickup 4 and the disk 3 when writing or reading data in the direction vertical to the plane of the disk 3 and the vibration due to the natural vibration of the disk face from the inside to the outside of the mechanism in the direction vertical to the disk plane, and by damping by means of the high-elasticity body 7 the self-producing vibration caused by disk rotation in the disk face direction. A material having a loss factor of tan δ =0.01 or more and a high internal damping property is effective as a high-elasticity body used for this.

Another embodiment as shown in Fig. 3 is characterized by forming a low-elasticity body into a hollow cylinder in which upper and lower parts 1a and 1b are increased in diameter and a central part 1c is decreased in diameter so that the low-elasticity body is inserted into and engaged with a hole formed in the mechanical chassis 2 of an optical disk unit, by improving the vibration isolation characteristics in the vertical direction by decreasing the spring constant in the direction vertical to the disk face, by disposing the high-elasticity body 7b to the axis side of the central small-diameter part 1c, and thereby by forming a composite elastic body with improved vibration isolating characteristics in the direction parallel with the disk face.

The damper shown in Fig. 4 is characterized by dividing a high-elasticity body used for the whole or a part of the side central small-diameter part 1c serving as a portion installed to a mechanical chassis for supporting it in the direction parallel with the plane of the disk 3 or a box chassis into a plurality of pieces, and by radially disposing them in the low-elasticity body 1 so that crushing in the direction vertical to a push axis can be easily performed and each chassis can be easily engaged with a installing hole.

A composite damper of the present invention is manufactured by a method of forming a low-elasticity body and a high-elasticity body with a thermosetting or thermoplastic member by a metal mold which is a well known art and then of bonding the low-elasticity body and high-elasticity body, a method of forming either a low-elasticity body or high-elasticity body by a metal mold and then of inserting it into the remaining elastic body forming mold, or an insert-forming or dichroic-forming method of forming a low-elasticity body and a high-elasticity body with a thermoplastic member in accordance with injection forming.

A damper is manufactured by increasing the upper and lower parts 1a and 1b of an elastic body in diameter and decreasing the central part 1c of the elastic body in diameter, using the high-elasticity body 7b having an E value two times or more larger than the E value of the upper and lower parts of the elastic body for the inside of the central part 1c, by forming the high-elasticity body 7b into a ring shape by means of injection molding, by inserting the annular high-elasticity body into a low-elasticity body forming metal mold, and then by injection-molding the upper and lower parts 1a and 1b of the low-elasticity body.

As the elastic body material, styrene-based thermoplastic elastomer JIS A with Hs of 40 hardness and E value of 50 kg/cm^2 is used for the low-elasticity body material of the large-diameter parts 1a and 1b.

As other low-elasticity body materials, the following are given: natural rubber, chloroprene rubber, butyl rubber, silicone rubber, urethane rubber and thermoplastic elastomer (styrene, olefin, polyester, or urethane based). Elastomer with an E value of $1.0x10^{4k}g/cm^2$ or less is preferably used.

As the material of the high-elasticity body of the small-diameter part 7b, polypropylene (PP) with E of $2.0x10^{4g}g/cm^2$ is used and dampers were manufactured from three types of elastic bodies tan δ =0.005, tan δ =0.01, and tan δ =0.05.

As other high-elasticity body materials, the following resins are given:

the above elastomer, and polyethylene (PE), polyvinylchloride (PVC), polystyrene (PS), acrylonitrile, butadiene, styrene resin (ABS), polyamide (PA), polyacetal (POM), polycarbonate (PBT), polyethylene terephthalate (PET), polybutylene terephthalate (PBT), polyphenylene oxide (PPO), polyphenylene sulfide (PPS), epoxy resin (EP), silicone resin (SI), and polyurethane (PUR).

Vibration tests were performed using the embodiments 1 to 4 of the present invention which are composite elastic bodies manufactured as described above and comparative example 1 (conventional product) entirely made of the same elastic body.

The material of the comparative example 1 is butyl rubber and has the shape shown in Fig. 5 which is the same as that in Fig. 2.

The vibration test was performed by supporting a 150g mechanical chassis at four points with dampers, by exciting the chassis with the frequency of 100 Hz at which a disk resonates, and by measuring the acceleration on the mechanical chassis to the excitation acceleration of the vibration. Thus, the acceleration on the mechanical chassis to the excitation acceleration was obtained as a ratio (%). The results obtained are shown in Table 1 below.

By the measurement results in Table 1, it is found that the comparative example 1 and the embodiments 1, 2, and 3 have the same transmissibility of vibration in the direction vertical to the disk. However, in the case of the embodiment 4 having the shape shown in Fig. 3, the low-elasticity body was radially divided and arranged. Therefore, the natural frequency was lowered and thereby the transmissibility of vibration was also lowered, and the vibration isolating effect was improved.

As the measuring result of the acceleration (G value) according to a mechanical deflection test in the direction parallel with a disk, mechanical deflection occurred because the spring constant in the direction parallel with the disk was small, so a large G value resulted. In the case of the embodiment 1, as the spring constant was large, mechanical deflection was suppressed and the G value could be reduced to approximately 1/3 of the G value of a conventional damper. In the case of the embodiments 2, 3, and 4, the G value could be further reduced because a material having a large loss factor was used for the high-elasticity body.

Moreover, the G values in the direction parallel with a disk were measured when the ratio between E values of the high-elasticity body and low-elasticity body is 2, 20, and 200 times in the case of the shape shown in Fig. 2. A sample having the same shape and the ratio between E values of high- and low-elasticity bodies which is 1.5 times was used for the comparative example 2. The results obtained are shown in Table 2 below.

In Table 2, it is impossible to accurately read data from a disk because the comparative example 2 has a large G value equal to that of the comparative example 1 entirely made of the same elastic body and the mechanical deflection is large.

In the case of the embodiment 5 in which the E value of the high-elasticity body is two times that the low-elasticity body, the G value due to mechanical deflection was halved compared to the case of the comparative example 2 and no erroneous operation was observed. Moreover, when the E value is 20 times that of embodiment 6 and 30 times that of embodiment 7, the G value was reduced and preferable results were obtained.

From the above results, it is found that mechanical deflection can be reduced by setting the E value of the high-elasticity body to a value two times or more larger than that of the low-elasticity body and automatic vibration of a high-double-speed mechanics can be controlled.

Embodiments of the present invention are described above. However, these embodiments are just examples. The present invention allows other various shapes corresponding to the shapes (boss, pin, or setting) of the counterparts.

A damper according to the present invention makes it possible to realise the same vibration isolating effect in the direction vertical to a disk face as that of a conventional damper and suppress the vibration in the disk face direction by a combined structure with the high-elasticity body 7. A low-elasticity body provides a preferable effect by decreasing the E value of a rubber-like elastic body to $1.0\mathrm{x}10^{4\mathrm{k}}\mathrm{g/cm}^2$ or less in order to decrease the natural frequency of the damper. In the case of a high-elasticity body, a force for suppressing vibration, that is the vibration suppression effect, is obtained without resonating with the vibration in the disk face direction by setting the E value of the high-elasticity body to a value two times or more larger than that of the low-elasticity body. For example, when the spring constant ratio according to a shape is increased up to two times and the E value is increased up to two times, the total spring constant ratio is increased up to four times. Therefore, the natural frequency can be obtained by square root, and thus it is increased up to two times. Thereby, it is possible to lower the natural frequency in the direction vertical to the disk face and to raise the natural frequency in the direction of the disk face at both sides of a desired frequency.

Moreover, by setting tan δ of the high-elasticity body to 0.01 or more, it is possible to damp the self-producing vibration inside of the high-elasticity body and to further improve the vibration suppressing effect.

Furthermore, by forming a low-elasticity body into a hollow cylinder, it is possible to easily decrease the spring constant and improve the vibration suppression characteristics in the direction vertical to a disk face, without reducing the vibration suppressing effect in the disk face direction by the high-elasticity body.

Therefore, a damper according to the present invention is most suitable for vibration suppression and vibration isolation of acoustic equipment, video equipment, information equipment, or various types of precision instruments, particularly an apparatus using an optical disk medium such as a CD, CD-ROM optical disk, or photomagnetic disk.

Moreover, when mounting a damper according to the present invention on a unit, a high-elasticity body is divided into a plurality of pieces to be disposed in the radial direction. The high-elasticity body can be easily mounted because a spring crushed in the direction vertical to the damper axis is deformed as a low-elasticity body, and only a small force is required compared to a high-elasticity body which is not divided.

Furthermore, it is possible to insert-form a damper of the present invention by means of a general injection molder or to two-colour-form the damper with a plurality of metal molds by using a thermoplastic member as a material of a

low-elasticity body and high-elasticity body, to realise an automated and labour saving process, and thus to decrease the manufacturing process cost.

Table 1

	Comparative	Embodiment			
	1 (Fig. 5)	1 (Fig. 2)	2 (Fig. 2)	3 (Fig. 3)	4 (Fig. 4)
E value of low-elasticity body (kg/d)	50	50	50	50	50
E value of high-elasticity body (kg/d)	—	2.0×10^4	2.0×10^4	2.0×10^4	2.0×10^4
Tan δ of high-elasticity body	—	0.005	0.01	0.05	0.05
Vibration transmissibility (%)	10	10	10	10	5
Direction parallel with disk (G value)	2	0.7	0.5	0.4	0.4

Table 2

	Comparative	Embodiment		
	2	5	6	7
E value of low-elasticity body (kg/d)	50	50	50	50
E value of high-elasticity body (kg/d)	75	100	1000	10000
Direction parallel with disk (G value)	2	1	0.8	0.7

Claims

1. A push-type anisotropic damper for supporting a mechanical chassis (2) comprising a rotary portion (8) of a medium disk (3) and an optical transmitter or an optical receiver (4) in order to prevent vibration of an apparatus for storing or regenerating data in a non-contact disk information medium such as an optical disk and a photomagnetic disk, said damper being formed by combining two types of elastic bodies (1,7) or more having different $\underline{E}$ values (dynamic compression elastic modulus); and said $\underline{E}$ value of an elastic body (7) for supporting said mechanical chassis in the direction parallel with a disk face and damping the vibration in the parallel direction with said disk face to be used for a part or the whole of a section to be installed to said mechanical chassis or a box chassis is two times or more larger than said $\underline{E}$ value of an elastic body (1) for supporting the direction vertical to said disk face and damping the vibration in the vertical direction to said disk face.

2. A damper as claimed in claim 1, characterized in that said $\underline{E}$ value of said elastic body (1) used for a section part for supporting said mechanical chassis in direction vertical to said disk face is 1.0×10^{4k} g/cm^2 or less and a loss factor of said elastic body is 0.01 or more.

3. A damper as claimed in claim 1 or 2, characterized by comprising a hollow cylinder of which a lateral face center section is formed into a small-diameter portion so as to serve as a section to be installed to said mechanical chassis or box chassis for supporting the direction parallel with said disk face.

4. A damper as claimed in any of claims 1 to 3, characterized in that said elastic body (7) for supporting the direction parallel with said disk face is comprised of one cylinder or a plurality of pieces radially arranged.

5. A damper as claimed in any of claims 1 to 4, characterized in that both elastic bodies (1,7) are made of a thermo-setting member or thermoplastic member.

Fig. 1

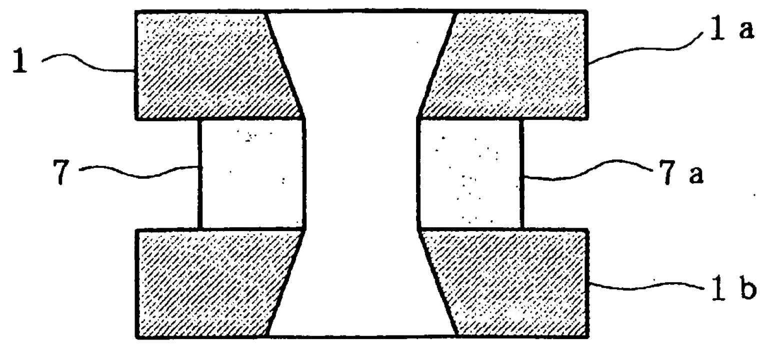


Fig. 2

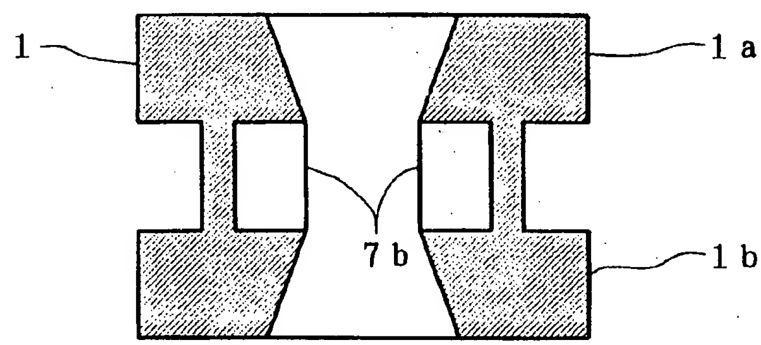


Fig. 3

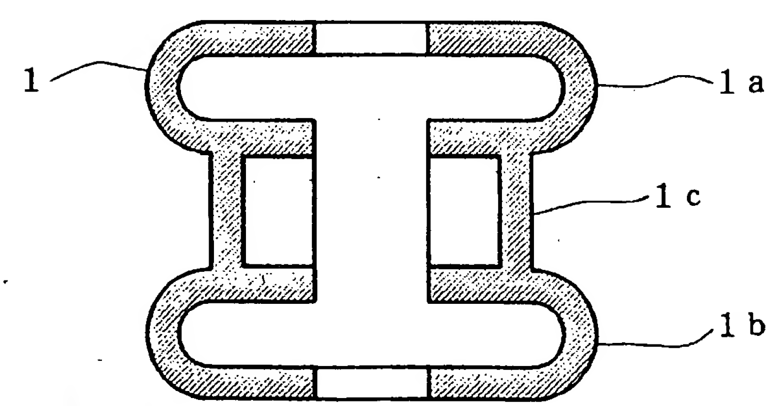


Fig. 4

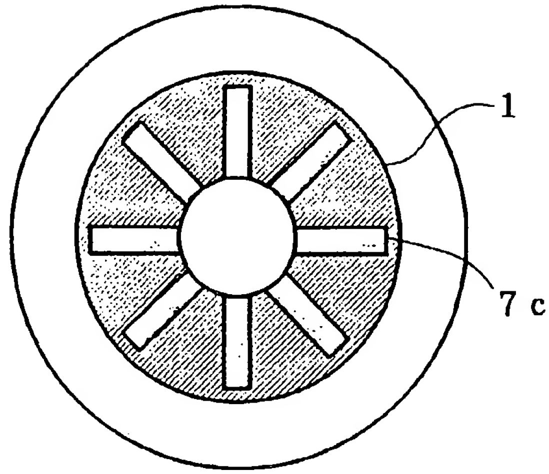


Fig. 5

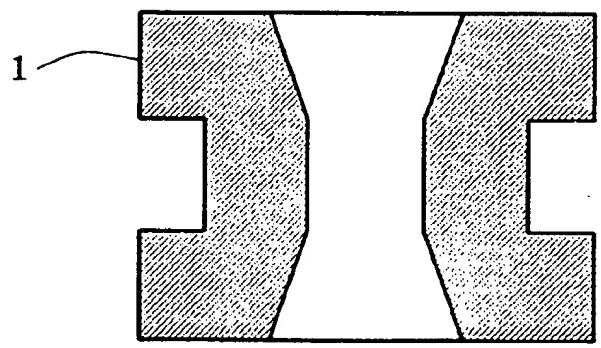


Fig. 6

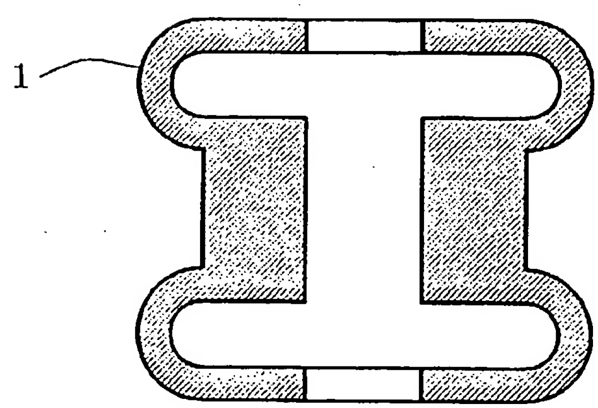
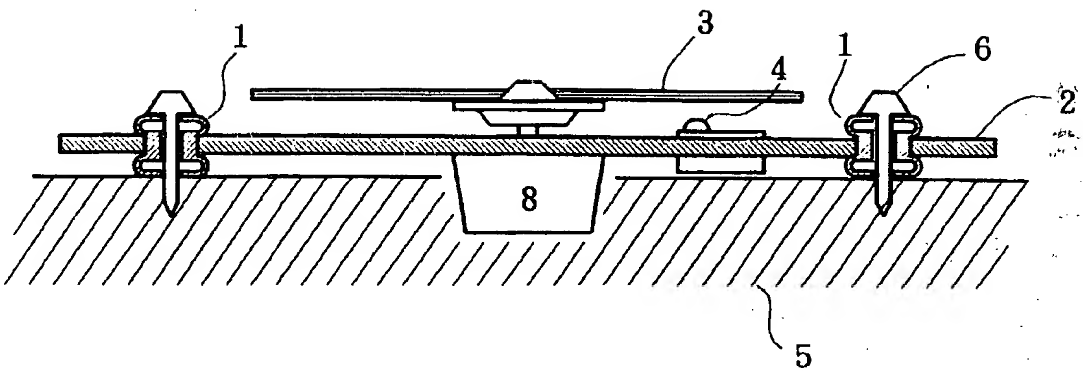


Fig. 7



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EUROPEAN SEARCH REPORT

Application Number
EP 97 30 7507

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X A	GB 452 858 A (HUGH COMPTON LORD) 27 August 1936 * page 1, column 2, line 59 - page 3, column 1, line 51; figures 1-13 *	1 2-5	G11B33/08 G11B19/20 F16F3/093
X A	EP 0 324 693 A (HUTCHINSON) 19 July 1989 * abstract; figures 1,2,7 * * column 8, line 14 - line 53 * * column 10, line 3 - line 9 *	1 2-5	
X A	US 3 399 851 A (RACCA ROMOLO) 3 September 1968 * abstract; figures 1-5 * * column 2, line 34 - column 3, line 20 * * column 3, line 55 - line 64 *	1 2-5	
A	DE 196 16 976 A (MITSUMI ELECTRIC CO) 31 October 1996 * abstract; figures 16A-18C * * column 25, line 22 - column 27, line 67 *	1-5	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	US 2 520 757 A (ROBERT M. CAIN) 29 August 1950 * column 2, line 29 - column 4, line 25; figures 1-4 *	1-5	G11B F16F
A	EP 0 197 159 A (SONY CORP) 15 October 1986 * abstract; figures 5-6D * * page 6, column 37 - page 10, column 11 *	1-5	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 January 1998	Pariset, N

CATEGORY OF CITED DOCUMENTS

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